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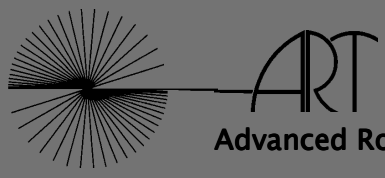
Federal Supply Service

Authorized Federal Supply Schedule Price List

Federal Supply Group 871 for Professional Engineering Services
Primary Engineering Disciplines
Electrical & Mechanical

SIN 871-3 System Design, Engineering and Integration

SIN 871-4 Test and Evaluation



Advanced Rotorcraft Technology, Inc.

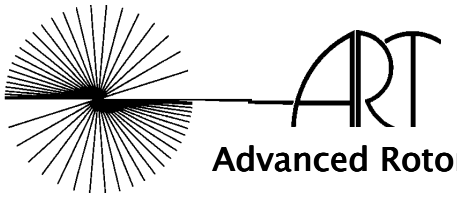
Contract Administrator: Donna Carrig
1330 Charleston Road • Mountain View, CA • 94043
(650)968-1464 • fax: (650)968-1978 • email: donna@flightlab.com

Advanced Rotorcraft Technology, a small business, is pleased to announce it has been awarded a five year contract (GS-10F-0332T) with the General Services Administration (GSA) to provide Professional Services in the following categories:

- **SIN 871-3 System Design, Engineering and Integration**
- **SIN 871-4 Test and Evaluation**

This contract is open for use by any government agency and allows the placement of requests for Professional Services up to $750,000.00 per individual order.

The following information is included in this document:



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Contact Information

www.flightlab.com

Authorized Federal Supply Service
Professional Services
GSA Schedule Contract Number: GS-10F-0332T

Period Covered By Contract:
August 2, 2007 through August 2, 2012
Special Item Number (SIN):
871-3 & 871-4 Professional Services

Contact:
Jeff Annis jannis@flightlab.com

Orlando Office: 407-292-2977

PROFESSIONAL SERVICES SKILL CATEGORY DESCRIPTIONS

Subject Matter Expert

General Summary:

Provides expertise in specific areas of engineering, such as propulsion systems, aerodynamics, structures control, handling qualities, etc.

Principal Duties and Responsibilities

Participates in project teams with Project Managers, Aerospace and Software Engineers to provide detailed analysis of specific engineering disciples relating to the project. May be responsible for formulating advanced mathematical modeling or analysis techniques. Reviews technical approach of project to assure soundness and participates in technical evaluations of project results.

Job Qualifications

Ph.D. or equivalent and 15 years experience in a specific discipline.

Senior Software Engineer

General Summary:

Designs software architectures required to support technical projects. Consults with aerospace engineers to understand functional requirements of required software. Applies established software development methodology to design, develop, implement and test new software. Applies established quality assurance and configuration management methods.

Principal Duties and Responsibilities

Performs high level software system design. Establishes software tools, quality assurance and configuration management methodology for software development. Provides training and advice to less experienced software engineers. Reviews software developed to his specifications to assure design goals have been achieved. Reviews software documentation developed to his

specifications to assure clarity and completeness.

Job Qualifications

Ph. D. or equivalent and 10 years experience in software development

Software Engineer

General Summary:

Designs, implements and tests software for specific functional applications. May implement and test high level software designed by senior software engineer under his direction.

Principal Duties and Responsibilities

Writes software applications and interfaces them with hardware or other software applications as required. Adheres to established standards of quality assurance and configuration management in developing the software. Coordinates with aerospace engineers to understand the software requirements. Documents all software in accordance with established documentation procedures.

Job Qualifications

Masters Degree in Computer Science or equivalent and 5 years experience in software development

Senior Aerospace Engineer

General Summary:

Performs a variety of aerospace engineering tasks, either independently or under supervision, which are broad in nature and are concerned with the design and implementation, including personnel, hardware, software and support facilities and/or equipment. Can also act as supervisor for team of engineers through project completion.

Principal Duties and Responsibilities:

Plans and performs aerospace engineering research, design development, and other assignments in conformance with design, engineering and customer specifications. Supervises team of Engineers through project completion. Responsible for major technical/engineering projects of higher complexity and importance than those normally assigned to lower level engineers. Coordinates the activities of Engineers and Technicians assigned to specific engineering projects. May perform other duties as required.

Job Specifications:

Ph.D. or equivalent and 10 years of experience

Aerospace Engineer

General Summary:

Develops mathematical models of aerospace systems for simulation and analysis. Uses these simulation models to assist in the design and testing of aerospace systems.

Principal Duties and Responsibilities:

Works under the direction of the Project Manager or the Senior aerospace Engineer. Carries out tasks related to engineering analysis of aerospace systems. Defines functional requirements for software implementation of mathematical models and coordinates with software engineers in the development of these models and associated analysis utilities. May write software for specific applications as required.

Job Specifications:

Masters Degree or equivalent and 5 years of experience

Junior Aerospace Engineer

General Summary:

Assists Aerospace Engineers in the development of mathematical models of aerospace systems for simulation and analysis. Assists in performing and documenting analyses.

Principal Duties and Responsibilities:

Works under the direction of the Aerospace Engineer. Carries out tasks related to engineering analysis of aerospace systems. Assists in the definition of functional requirements for software implementation of mathematical models and assists software engineers in the development of these models and associated analysis utilities. May write software for specific applications as required.

Job Specifications:

Masters Degree or equivalent

Experience

Advanced Rotorcraft Technology, Inc. (ART) was founded in June 1982 to provide specialized engineering consulting for all aspects of rotorcraft Technology. Our consulting activities required extensive simulation of rotorcraft so ART became familiar with all available rotorcraft simulation tools. As our expertise in rotorcraft grew we developed a rotorcraft dynamics modeling tool called FLIGHTLAB to assist us in our consulting work. ART began selling FLIGHTLAB commercially in 1990 and it has since become the leading commercial software tool for rotorcraft modeling and analysis. ART has continued to perform basic research into rotorcraft phenomena for NASA, the U.S. Army and the U.S. Navy and to support all major U.S. rotorcraft manufacturers in design and analysis of rotorcraft. ART areas of consulting have included structures, aerodynamics, propulsion, control, handling qualities, and test and evaluation. In the course of performing this consulting work, ART has used FLIGHTLAB to develop models of all major U.S. Military helicopters and many U.S. and foreign civil helicopters. In 1995 ART began selling flight dynamics models we had developed with FLIGHTLAB into the training simulator industry. In 2000 we contracted with L3 Communications Link Simulation and Training Division to provide all the flight dynamics models for the Aviation Combined Arms Tactical Training (AVCATT) Simulators they developed for the U.S. Army. Today more than 600 of our flight dynamics models are in use in Military training simulators from mission training simulators to Operational Flight Training simulators. In addition to rotorcraft, ART has expanded FLIGHTLAB to address modeling and analysis of fixed wing aircraft.

In 1998 ART developed the Rotorcraft Comprehensive Analysis System (RCAS) by combining elements of our FLIGHTLAB rotorcraft modeling and analysis environment with rotorcraft components that had been developed for the Army's Second Generation Comprehensive Helicopter Analysis System (2GCHAS). Under a Cooperative Research and Development Agreement (CRADA) with the U.S. Army in 2000, ART agreed to support our RCAS system as a non proprietary tool for U.S. Government applications and the Army agreed to assist ART in obtaining the engineering data needed to develop and validate models of all Army helicopters. RCAS and FLIGHTLAB are now extensively used as complementary and interchangeable rotorcraft modeling environments by the U.S. Government.

Since 2000 ART has also pursued developing turnkey simulators utilizing our flight dynamics models. Our HeliFlight line of simulators supports both reconfigurable and aircraft-specific simulators with varying degrees of fidelity. Providing hardware that has been integrated with our modeling software presents a very cost effective solution to our customers.

ART's main office is located in Mountain View, California, near Stanford University and the Ames Research Center. We also have a sales office in Orlando, FL. Our staff includes 18 employees with predominantly Ph. D's and Masters Degrees in Aerospace Engineering. We have performed rotorcraft consulting for 25 years and collectively our staff has over 100 years of experience in rotorcraft engineering. Our Primary Engineering Disciplines include Mechanical Engineering and electrical Engineering with sub disciplines of aeronautics, propulsion, structures, control, handling qualities, test and evaluation, and modeling and analysis. We have extended our rotorcraft expertise to support the wind turbine industry with both the RCAS and FLIGHTLAB programs supporting wind turbine modeling and analysis.

Due to our extensive experience, research and DOD partnering, ART has the unique capability to offer an overall solution in a cost effective manner to our customers.

ART Projects by GSA contract SIN

I. SIN 871-3 SYSTEM DESIGN, ENGINEERING AND INTEGRATION

Here's a GSA description of this SIN#. Following is a list of Projects we have worked on relating to this SIN #

Services required under this SIN involve the translation of a system (or subsystem, program, project, activity) concept into a preliminary and detailed design (engineering plans and specifications), performing risk identification/analysis/mitigation, traceability, and then integrating the various components to produce a working prototype or model of the system. Typical associated tasks include, but are not limited to computer-aided design, design studies and analysis, high level detailed specification preparation, configuration management and document control, fabrication, assembly and simulation, modeling, training, privatization and outsourcing.

Example: The navigation satellite concept produced in the preceding stage will be converted to a detailed engineering design package, performance will be computer simulated and a working model will be built for testing and design verification.

Architect-Engineering (A/E) Services as that term is defined in FAR 36.601-3 are excluded from the PES Schedule. If the agency's statement of work, substantially or to a dominant extent, specifies performance or approval by a registered of licensed architect or engineer for services related to real property, the Brooks Architect-Engineers Act applies and such services must be procured in accordance with FAR Part 36. Use of this schedule for Brooks Act architectural or engineering services is not authorized. Inappropriate use of this SIN is providing professional engineering services not specifically related to system design, engineering and integration and associated disciplines.

To see additional information about these projects, click on the project #.

Project 1: Innovative Rotorcraft Flight Control Systems Options to Enhance Shipboard Operations. *Develop a flight control design environment to facilitate the design of control systems for shipboard operations.*

Project 2: Real-Time Modeling of Rotor Induced Flow with Shipboard Interaction.
Develop a viscous vortex wake model that can properly capture the effects of the rotor/ship interaction

Project 3: Design and Analysis of a Compound Helicopter for High Speed Flight
Use ART modeling and analysis tools RCAS and FLIGHTLAB to design and simulate a compound helicopter that uses a variable speed rotor for efficient autorotative lift in high speed forward flight

Project 4: HeliFlight-R - *Develop a reconfigurable simulator to support engineering applications*

Project 5: Aeroelastic Modeling of a Long Endurance Fixed Wing UAV - *Use ART modeling and analysis tool RCAS to design and simulate a Long Endurance Fixed Wing UAV*

Project 6: **HI-ARMS** - *Coupling of Comprehensive Structural Analysis Codes to Computational Fluid Dynamics Codes for advanced Modeling and Simulation*

Project 7: **H-60M helicopter Upgrade Program** - *Use ART modeling and analysis tool FLIGHTLAB to design and simulate upgrades to the H-60M helicopter*

Project 8: **Waypoint Following** - *Design and testing of a trajectory following autonomous control system for a UAV*

Project 9: **Sensor Visualization** - *Develop visualization tool for Apache helicopter electro-optical sensor blind spots*

Project 10: **CH-53 Aeroelastic Simulation Model**

Project 11: **Ducted Fan Model** - *Develop a ducted fan model in FLIGHTLAB that includes blade element modeling of the rotor, panel method modeling of the duct, and mutual interaction between the rotor and duct.*

Project 12: **OH-58D Model for Flight School XXI** –
Integration and Testing of OH-58D flight dynamics model with Rockwell simulator for U.S. Army Flight School XXI

Project 13: **Sling Load Modeling for Handling Qualities Analysis** - *Modeling and validation of sling loads for handling qualities analysis*

Project 14: **HeliQuiet** - *Couple RCAS with CFD codes to provide a design environment for quieter rotor blades*

Project 15: **Advanced Multi-Aircraft Shipboard Landing Model** - *Model aerodynamic interaction of multiple aircraft in a shipboard environment*

Project 16: **OH-58D Simulator for Advanced Rotorcraft Training Services** - *Designed, developed and certified to FAA Level D standards a simulator of the OH-58D helicopter.*

Project 17: **Lift Simulation for Helicopters Improvement Program (LSHIP)**
Integration and testing of FLIGHTLAB UH-60 flight dynamics model with shipboard landing on a U.S. Army Operational Flight Trainer

Project 18: **CHSSI – HPC RCAS** - *Integration of RCAS with Overflow CFD program and testing with CH-47 model*

Project 19: **DASH SIM -** *Integration and testing of FLIGHTLAB UH-60 flight dynamics model with Army research simulators. Integration with tactical environment and visual display using HLA.*

Project 20: **Ship Dynamics/Ship Air Wake Interface** - *Enhanced ship airwake integration with ship model and flight dynamics model*

Project 21: **Generation of Consistent Rotorcraft Dynamic Models for Life Cycle Simulation Support -** *Utilize simulation models traceable to a common comprehensive simulation model for all stages of flight vehicle life cycle; Conceptual design to pilot training.*

Project 1: Innovative Rotorcraft Flight Control Systems Options to Enhance Shipboard Operations

Summary of Services Performed: Develop a flight control design environment to facilitate the design of control systems for shipboard operations.

Rotorcraft shipboard operations have been an essential but demanding aspect of modern maritime activities. The shipboard rotorcraft are strongly affected by the unsteady ship airwake and the dynamic ship motion. Significant progress has been made in analyzing these effects on the shipboard operating rotorcraft. There is, however, a lack of research for applying these analytical modeling capabilities to the development of advanced flight control systems in order to benefit the rotorcraft shipboard launch and recovery operations by enhancing flight safety and reducing pilot workload. This proposal aims at developing a unified rotorcraft flight control design and evaluation environment to facilitate a systematic development of advanced rotorcraft flight control system algorithms. The proposed research will (1) develop innovative rotorcraft flight control system algorithms to account for the effects of the shipboard operating environment; (2) develop a shipboard rotorcraft simulation environment to facilitate accurate plant and disturbance model generation and control design evaluation in support of advanced flight control model development; (3) prototype a control toolkit that can be used with user customized modeling and simulation environment;(4) integrate the control design toolkit into a comprehensive rotorcraft/ship simulation program to demonstrate the functionality and investigate the effects of the ship airwake and the ship motion on rotorcraft performance and dynamics.

Project 2: Real-Time Modeling of Rotor Induced Flow with Shipboard Interaction

Summary of Services Performed: Develop a viscous vortex wake model that can properly capture the effects of the rotor/ship interaction**.**

Rotor induced flow modeling is a central part for almost every aspect of rotorcraft simulation and analysis. There are, however, challenges in accurately predicting the unsteady rotor wake transportation, especially when it interacts with aerodynamic disturbances from nearby aerodynamic bodies such as a fuselage, a ground surface, or a ship landing deck. This proposal aims to develop an adequate real-time rotor induced flow model for shipboard flight simulation. The model to be developed will be a physics-based viscous vortex wake model that can properly capture the effects of the rotor/ship interaction under shipboard operating conditions. It is also proposed to develop a formulation and a set of algorithms to derive an efficient real-time finite state induced flow model from the high fidelity viscous vortex simulation in support of flight simulation.

Project 3: Design and Analysis of a Compound Helicopter for High Speed Flight

Summary of Services Performed: Use ART modeling and analysis tools RCAS and FLIGHTLAB to design and simulate a compound helicopter that uses a variable speed rotor for efficient autorotative lift in high speed forward flight

ART was awarded a subcontract to support the design and analysis of a compound helicopter named Heliplane. The configuration used a rotor with tip-jets to fly as a helicopter in hover and low speed forward flight and as a fixed-wing aircraft with the rotor in auto-rotative mode in high speed (up to 400 mph). In such a configuration, the rotor would experience an advance ratio of up to 2.7. ART created two models for this configuration: one in RCAS for engineering analysis and the other in FLIGHTLAB for flight dynamic analysis. Since the trim for this compound helicopter was not unique, ART developed a new trim algorithm for the entire flight envelope. In addition, a preliminary RPM control system was designed and implemented for the high advance ratio auto-rotative condition.

Project 4: HeliFlight-R

Summary of Services Performed: Develop a reconfigurable simulator to support engineering applications

ART has developed HeliFlight-R, a reconfigurable simulator that can be coupled with FLIGHTLAB flight dynamics models to support pilot-in-the-loop engineering analysis. The initial system was purchased by the U.S. Navy at Patuxent River, MD to support planning of shipboard landing tests. The HeliFlight-R system is being delivered with two different flight dynamics models and cockpit configurations; the SH-60 and the V-22. The Navy will use it to simulate planned ship/helicopter trials to make the most efficient use of available flight test time. A second HeliFlight–R system is being developed for a major Aerospace University and will be used to support Handling Qualities evaluation of new European aircraft such as the European tilt rotor.

HeliFlight-R includes a 12 ft. diameter dome with three SXGA projectors capable of rendering a 210 x 60 degree field of view. A set of four axis control loaders are used to provide the aircraft-specific control feel characteristics and LCD displays are used to display computer generated instruments and MultiFunction displays for the reconfigurable cockpit. The system for the U.S. Navy will include a Quantum3D Image Generator with a dynamic sea state and an LHA ship display for shipboard landing work.

Project 5: Aeroelastic Modeling of a Long Endurance Fixed Wing UAV

Summary of Services Performed: Use ART modeling and analysis tool RCAS to design and simulate a Long Endurance Fixed Wing UAV

ART was awarded a contract to support the development of an aeroelastic model for a long endurance fixed-wing UAV. In this project RCAS was extended to compute wing airloads as a function of angle of attack and Reynolds number as opposed to angle of attack and Mach number. Wing vortex wake, Von Karman/Dryden gust models and nonlinear unsteady

Leishman-Beddos airloads option for wing flaps, aileron and tail elevator were also added. This model is currently being used for flutter analysis.

ART has also supported the modeling of the Comanche Bearingless Main Rotor (BMR). This involved enhancing components and utilities to facilitate analysis of the Comanche Regressing Lag Mode (RLM) phenomena. In addition, ART has supported modeling of the CH-47 Improved Cargo Helicopter (ICH) in RCAS.

Project 6: HI-ARMS

Summary of Services Performed: Coupling of Comprehensive Structural Analysis Codes to Computational Fluid Dynamics Codes for advanced Modeling and Simulation

ART is currently under contract to couple the ART comprehensive modeling and analysis code RCAS to new advanced CFD modules for the HI-ARMS program. As a part of this SBIR, RCAS has been modified to be run under Python, an interpretive interface language, in the same manner as the CFD modules. In this approach, the interface between RCAS and CFD via input/output file system is bypassed and the data transfer is accomplished via memory access, which is faster for the tight coupling.

Project 7: H-60M helicopter Upgrade Program

Summary of Services Performed: Use ART modeling and analysis tool FLIGHTLAB to design and simulate upgrades to the H-60M helicopter

ART is supporting both the U.S. army Aviation Engineering Division at Huntsville, AL and other commercial companies in their effort to improve the lift and performance of the H-60M helicopter. This project involves using FLIGHTLAB to perform modeling and analyses In support of the UH-60M helicopter upgrade program for an increased lifting capability and performance in order to operate under severe flight conditions. The modeling and simulation support includes the development of GE's CT7-8B engine simulation model in FLIGHTLAB and integration of the engine with H-60M rotor/airframe model for a coupled multi-dissimilar engine failure analysis. The integrated nonlinear engine/rotor/airframe simulation also supports the drivetrain stability and autorotation analysis to provide pre-flight test analysis for an enhanced flight test productivity and safety. ART also successfully developed a high order rotor interference model that can accurately predict the asymmetric horizontal loads due to the impingement of the rotor downwash on the stabilator. Finally, efforts were also made in enhancing the blade element H-60M simulation model to support MH-60M airframe loads prediction under both steady and unsteady maneuvering flight conditions.

Project 8: Waypoint Following

Summary of Services Performed: Design and testing of a trajectory following autonomous control system for a UAV

ART was awarded a contract by ARI to develop and implement a trajectory following algorithm for an autonomous aircraft. The main goal of the project was to develop an autonomous

navigation algorithm that commands the aircraft to follow a sequence of waypoints. The navigation algorithm was designed to generate command inputs for the existing controller. The navigation algorithm includes roll, pitch, and throttle commands. ART developed the algorithm and the code and integrated to a simulation of the aircraft. The simulation tested from many input scenarios and delivered to ARI. The effectiveness and robustness of the algorithm and the code were verifies by the completion of successful flight tests.

Project 9: Sensor Visualization

Summary of Services Performed: Develop visualization tool for Apache helicopter electro-optical sensor blind spots

Under contract to the Army's Aviation Technical Test Center (ATTC) at Ft. Rucker, Al. ART developed a software graphics tool to assist in visualizing the regions in the air and ground space around a helicopter that were not observable by the electro-optical sensors on the helicopter. The cone of observability for each sensor on the helicopter was rendered along with the helicopter and the terrain and the shadow produced by the tail of the helicopter for rearward looking sensors was overlaid on this observability cone. Several different ways of rendering the display were implemented to provide alternate views. In one view the space covered by the sensors was rendered and in another view the space not covered by the sensors was rendered. The observer can set the eyepoint using the mouse to move closer to and further away from the helicopter as well as to translate and rotate in the space around the helicopter to customize the viewpoint. The helicopter can be moved in the space over the terrain from a mission plan to identify the vulnerable areas where ground and air launched missiles may not be detectable. This software has now been deployed in Iraq and Afghanistan to support mission planning for helicopter sorties.

Project 10: CH-53 Aeroelastic Simulation Model

Summary of Services Performed: Develop RCAS model of CH-53 for aeroelastic analysis
ART is supporting Sikorsky Aircraft in modeling the CH-53 helicopter in the RCAS. The focus of this effort is on detailed aeroelastic modeling and running tests under high load factors. ART provided number of reports analyzing the results of RCAS in comparison with flight tests. Among them the identification of Floquet Transition Matrix roots and the effects of elastic swashplate on the aeroelastic stability of the rotor can be named.

ART is also supporting an aircraft manufacturer in modeling new coaxial rotor helicopter UAV in RCAS. This manufacturer is using RCAS to analyze the mutual interference of the two rotors.

Project 11: Ducted Fan Model

Summary of Services Performed: Develop a ducted fan model in FLIGHTLAB that includes blade element modeling of the rotor, panel method modeling of the duct, and mutual interaction between the rotor and duct.

The ducted/shrouded fan has become widely adopted in modern rotorcraft as a safe, low noise, and effective anti-torque device. Ducted fans have also found popular applications as the main VTOL lifting device for recent uninhabited air vehicle (UAV) and flying automobile developments because of their compact structure and high lifting performance. The proposed research is dedicated to developing a high fidelity and efficient ducted fan modeling and simulation tool for helicopter anti-torque and UAV lifting applications. The development will focus on the following:

(1) The development of an efficient blade element fan model that can be applied for ducted fan performance, stability, and control analysis and simulation.

(2) The development of duct aerodynamic models with selective fidelity to address the duct lift augmentation effect and duct drag and moment variations in both axial and cross-wind conditions.

(3) The development of a coupled duct-fan model that allows for mutual aerodynamic interaction of the duct and the fan. Efforts will also be made to develop an effective and efficient rotor/airframe/duct/fan aerodynamic interaction model. The model will provide a comprehensive modeling tool to support the simulation of rotorcraft and VTOL air vehicles equipped with ducted fan devices.

Project 12: OH-58D Model for Flight School XXI

Summary of Services Performed: Integration and Testing of OH-58D flight dynamics model with the simulator for U.S. Army Flight School XXI

Under a contract ART has provided a flight dynamics model of the OH-58D helicopter and assisted in its integration and acceptance testing with two Operational Flight Trainers. The flight dynamics model was developed using ART's FLIGHTLAB Development System, a computer aided engineering tool for flight dynamics modeling and analysis. The trainers were tested to FAA Level D certification standards. This effort involved the integration of the flight dynamics software the cockpit, motion platform, visual display system, control loaders and Instructor Operator Station (IOS). The response of the flight dynamics model was compared to experimental flight test data for a wide range of flight conditions and maneuvers and the model was tuned to satisfy the tolerances required by the acceptance testing. The quantitative comparison between simulator and flight test data was automated to allow for field monitoring of the simulator readiness. Simulator hardware was also included in the automated quantitative testing. Over 50 malfunctions were implemented and tested. Qualitative testing was performed by experienced OH-58D pilots flying the simulator through the training tasks currently being trained in the actual aircraft. The simulators have now been delivered to Ft. Rucker, AL and are being used in the Army's Flight School XXI program.

Project 13: Sling Load Modeling for Handling Qualities Analysis

Summary of Services Performed: Modeling and validation of sling loads for handling qualities analysis

Slung load handling is a unique capability of rotorcraft widely applied in support of cargo transportation, rescue, and the special construction in areas where no other air or ground vehicles can operate. The presence of a sling load can degrade rotorcraft handling qualities and reduce the flight envelope. This project has successfully developed a multi-body and unsteady rotorcraft/sling load modeling and simulation tool in FLIGHTLAB for an accurate assessment of

the sling load dynamic stability and the operational envelope. The sling load modeling tool developed can simulate arbitrary sling load configuration under influence of unsteady sling load airloads. The coupled rotorcraft/sling load modeling tool developed was applied for simulating the sling load operation of UH-60L and CH-47D helicopter. The simulation results were compared with measured sling load flight test data and a very satisfied agreement was obtained. The simulation model was also integrated with ART's HeliFlight simulator and a pilot-in-the-loop evaluation was conducted that further validated the simulation.

Project 14: HeliQuiet

Summary of Services Performed: Couple RCAS with CFD codes to provide a design environment for quieter rotor blades

Helicopter Quieting Program (University of Maryland/Stanford University)
As a part of DARPA's **Helicopter Quieting Program** (HPQ), ART supported the integration of RCAS with the CFD code from Stanford University (SUmb). This activity involved the development of UH-60 aeroelastic rotor model and analysis of the model in high speed, low speed and high thrust conditions. The results of the coupled code compared well with flight test results.

Helicopter Quieting Program
As a part of DARPA's **Helicopter Quieting Program** (HPQ), ART supported the integration of RCAS with the Rockwell Scientific CFD code WINDUS. This activity involved the development of UH-60 aeroelastic rotor model and analysis of the model in high speed, low speed and high thrust conditions. The results of the coupled code compared well with flight test results. In addition, ART developed an aeroelastic rotor model of HART II and completed the required initial runs prior to the coupled CFD-RCAS runs.

Project 15: Advanced Multi-Aircraft Shipboard Landing Model

Summary of Services Performed: Model aerodynamic interaction of multiple aircraft in a shipboard environment

The goal of this SBIR was to develop physically based advanced aircraft/ship dynamic and aerodynamic interaction models to support multi-aircraft shipboard landing simulation. The work emphasized the development of critical modeling components for the multi-aircraft interaction including an advanced horseshoe vortex model for wing interference and an advanced finite state dynamic wake module and time-accurate distorted vortex model for rotor wake solution. To fully address the complicated multi-aircraft/ship interaction, efforts were also made toward a comprehensive integration of each modeling aspect including ship dynamics, ship airwake, high fidelity rotorcraft blade element model, accurate landing gear modeling, rotor wake/ship deck aerodynamic interaction, and rotor wake interference.

The development of multi-aircraft interference modeling and simulation will strongly benefit aircraft shipboard operations and support the process of design, training, and planning. It will also benefit commercial airlines for take-off and landing safety and improvement of terminal area operation efficiency.

The following is additional reference information:

SBIR Topic Number: N03-034

Title: Advanced Multi-Aircraft Shipboard Landing Model

Significant breakthroughs have been made through this SBIR in developing advanced rotor wake interference models in support of land-based and shipboard rotorcraft operations. Both a high order finite state dynamic wake interference model and a time-accurate distorted vortex interference model have been developed for multi-aircraft aerodynamic interaction simulation. To accurately predict complicated shipboard multi-aircraft interference, the effects of the unsteady ship airwake were also addressed. An efficient ship airwake model was developed which can be used as a practical tool for ship airwake and rotor downwash interaction study. The advanced rotor interference models developed can be applied for aircraft spacing and air traffic control analysis and simulation. Coupled with an unsteady ship airwake interference model, the rotor wake interference model can also provide a unified formulation for multi-aircraft shipboard landing analysis and simulation.

Project 16: OH-58D Simulator for Advanced Rotorcraft Training Services

Summary of Services Performed: Designed, developed and certified to FAA Level D standards a simulator of the OH-58D helicopter.

ART has developed the OH-58D HeliFlight-S as a prototype for Advanced Rotorcraft Training Services (ARTS), a company that will be setting up helicopter training centers using this and future simulators developed by ART. The simulator includes a 225 degree by 90 degree dome display for the visual system and a four axis set of control loaders to back drive the pilot and copilot controls. All instruments and switches in the high fidelity cockpit are functional but only those related to flight dynamics training tasks are operational. The rest can be added as required. An Instructor/Operator Station provides control of simulation operations including initialization, data monitoring and recording, and the initiation of malfunctions. A set of six monitors repeat the out the window scenes, instrument displays and provide a control console. The simulator flight dynamics model was tested quantitatively to FAA Level D standards by comparison with experimental test data and the total simulator was tested qualitatively to Level D standards for tasks in the Aircrew Training Manual related to flight dynamics. The qualitative testing was performed with the assistance of the Army Research Institute at Ft. Rucker and utilized 12 OH-58D pilots over a six month period while the simulator was located at Ft. Rucker. The simulator is currently situated at ART's office in Mountain View, CA and is being used to support engineering analysis and marketing efforts by ARTS for their training centers.

This project required extensive engineering design of mechanical and electrical systems to fabricate the cockpit, the control linkages, the switches and displays, and the dome and projectors. Extensive integration of system software was required including the flight dynamics model, the image generator, and the Instructor/Operator Station (IOS) software console. Quantitative testing of the flight dynamics model included extensive correlation against experimental flight test data for the aircraft. Qualitative testing of the complete simulator was performed by experienced OH-58D pilots at Ft. Rucker and ART modified simulator systems as

required to satisfy their requirements. The deliverables to the customer included the OH-58D simulator, documentation of the qualitative and quantitative tests, system documentation, and an operator's guide.

Project 17: Lift Simulation for Helicopters Improvement Program (LSHIP)

Summary of Services Performed: Integration and testing of FLIGHTLAB UH-60 flight dynamics model with shipboard landing on a U.S. Army Operational Flight Trainer

Under a prime contract from the Army's PEOSTRI, ART provided a UH-60 flight dynamics model that included our latest shipboard landing modeling capability and assisted in integrating and testing it with an existing UH-60 Operational Flight Training simulator at Ft. Campbell. The model included the effect of the ship airwake on the helicopter. The ship airwake was generated using Computational Fluid Dynamics with a detailed model of the ship's geometry. ART also provided a nonlinear six degree of freedom motion of the ship and used it to drive a visual representation of the ship in the simulator. Other helicopter ship interactions included the dynamic ground effect of the ship moving under the helicopter, the partial ground effects resulting from a rotor partially over the deck, and the interaction between the helicopter landing gear and the deck. Several pilots that were experienced with shipboard helicopter operations were brought in to test the flight dynamics model and simulator. Their conclusion was that the simulator was very representative of the helicopter shipboard landing and that the addition of an accurate airwake from the ship's superstructure was an essential part of the realistic training environment.

Project 18: CHSSI – HPC RCAS

Summary of Services Performed: Integration of RCAS with Overflow CFD program and testing with CH-47 model

As part of the High Performance Computing and Modernization Program (HPCMP) under the Collaborative Simulation and Testing (CST-05) portfolio, ART was tasked to support the integration/interface of RCAS with OVERFLOW**.** Under this contract, ART performed, designed, and implemented the automatic RCAS-OVERFLOW coupling in RCAS. The setup for the CH-47 tandem rotor configuration was completed and an initial run was made in hover. A nonlinear transient response and maneuver were performed for the UH-60 isolated rotor.

Project 19: DASH SIM

Summary of Services Performed: Integration and testing of FLIGHTLAB UH-60 flight dynamics model with Army research simulators. Integration with tactical environment and visual display using HLA.

Under a contract to the U.S. Army Aeroflightdynamics Directorate, ART integrated FLIGHTLAB models of the UH-60 helicopter with two cockpits and helmet mounted display systems that had previously been used with the Crew Station Research and Development Facility (CSRDF) at the Ames Research Center. The flight models were integrated with the STRIVE tactical environment from CAE and with the XIG Image Generation System from CATI using

the Higher Level Architecture (HLA) for distributed simulation. The HLA interface allowed the two helicopter simulators to perform as free flight players in the Strive tactical environment.

Project 20: Ship Dynamics/Ship Air Wake Interface
Summary of Services Performed:
Enhanced ship airwake integration with ship model and flight dynamics model

All previous shipboard rotorcraft analyses were based on the ship airwake variation generated from a steady ship forward motion. This research focused on investigating the effects of unsteady ship motion and the ship airwake generated from that motion on the shipboard rotorcraft flight dynamics. The study showed remarkable effects of the ship motion on the shipboard rotorcraft flight dynamics. An advanced turbulent ship airwake model was derived that reflects the effects of the ship motion. This research also developed modeling technology for the rotor/ship aerodynamic interaction that addresses the unique aerodynamic phenomena under shipboard operational conditions, including partial and dynamic ship deck effects and the interaction of the rotor downwash with the ship airwake. The development of shipboard rotorcraft flight control options can greatly benefit from these advanced modeling features.

Project 21: Generation of Consistent Rotorcraft Dynamic Models for Life Cycle Simulation Support
Summary of Services Performed: Utilize simulation models traceable to a common comprehensive simulation model for all stages of flight vehicle life cycle; Conceptual design to pilot training.

Recent advances in simulation technology have increased the emphasis on the use of simulation throughout a vehicle's life cycle. Simulation models are currently used to support design, operational analysis, test and evaluation, and training, but these models have been independently generated and are not subject to compliance with any standards. As a result the simulation models currently in use are inconsistent, difficult to maintain and upgrade, and vary greatly in their ability to support these applications.

This SBIR accomplished the rotorcraft simulation model standardization by focusing on rotorcraft conceptual design and the handling quality analysis process. ART's comprehensive rotorcraft modeling and simulation program, FLIGHTLAB, has been used to develop specialized blade element dynamic models to support rotorcraft both conceptual design and flying qualities evaluation.

The Phase I of this SBIR successfully accomplished the development of high fidelity rotorcraft simulation model for generating design database for rotorcraft conceptual design. The Phase II accomplishments include:

(1) Development of functional requirements for specialized rotorcraft dynamic models for use in handling qualities analysis;
(2) Development of a comprehensive plan for verification, validation, and accreditation (VV&A) of the rotorcraft handling qualities dynamic models;
(3) Development of blade element models in FLIGHTLAB for the three example helicopters for handling qualities applications.
(4) Performance of validation testing of the blade element models for performance, stability, and control response prediction against measured data to demonstrate the model VV&A process.

II. SIN 871-4 TEST AND EVALUATION

Here's a GSA description of this SIN#. Following is a list of Projects we have worked on relating to this SIN #

Services required under this SIN involve the application of various techniques demonstrating that a prototype system (subsystem, program, project or activity) performs in accordance with the objectives outlined in the original design. Typical associated tasks include, but are not limited testing of a prototype and first article(s) testing, environmental testing, independent verification and validation, reverse engineering, simulation and modeling (to test the feasibility of a concept), system safety, quality assurance, physical testing of the product or system, training, privatization and outsourcing.

Example: The navigation satellite-working model will be subjected to a series of tests, which may simulate and ultimately duplicate its operational environment.

Architect-Engineering (A/E) Services as that term is defined in FAR 36.601-3 are excluded from the PES Schedule. If the agency's statement of work, substantially or to a dominant extent, specifies performance or approval by a registered of licensed architect or engineer for services related to real property, the Brooks Architect-Engineers Act applies and such services must be procured in accordance with FAR Part 36. Use of this schedule for Brooks Act architectural or engineering services is not authorized. Inappropriate use of this SIN is providing professional engineering services not specifically related to testing and evaluating and associated disciplines.

Project 1: Advanced Aircraft Simulator Flight Fidelity Evaluation Measures - *Develop new methodology to evaluate the fidelity of flight simulators that relies completely on quantitative measures.*

Project 2: Handling Qualities Specification Requirements for Maritime Rotorcraft, VTOL UAV, and Heavy Lift Helicopters - *Developing an aeronautical design standard and simulation toolbox to address the urgent needs of rotorcraft, heavy lift helicopter, and VTOL UAV handling qualities requirements for shipboard operations.*

Project 3: Enhanced Rotorcraft Aerodynamic Modules to Support Flight Testing
Developed advanced rotorcraft aerodynamic modules to significantly enhance and improve the analytical prediction of rotorcraft performance, flying quality, and loads in support of vehicle design, manufacturing, operation, and flight testing.

Project 4: Enhanced Rotorcraft Aerodynamic Modules to Support Flight Testing
Develop computationally scalable software to utilize massively parallel computer systems to efficiently predict performance and stability in support of flight testing.

Project 1: Advanced Aircraft Simulator Flight Fidelity Evaluation Measures

Summary of Services Performed:
Develop new methodology to evaluate the fidelity of flight simulators that relies completely on quantitative measures.

While new technology is making flight simulators more affordable, validating the simulators for training applications remains costly. This is mostly due to the inefficiency and inconsistency of the subjective validation approach currently used. Performing trial and error iterations based on the subjective opinion of multiple pilots is costly and inefficient. A major deficiency in the current validation approach is the inability to separately determine the validity of the simulator cueing systems. The subjective validation is end-to-end and the flight dynamics model, after initially being validated in isolation, is ultimately modified to compensate for cueing deficiencies in the total system. Advanced Rotorcraft Technology, Inc. (ART) has proposed a new validation criteria and methodology that provides a quantitative metric for the fidelity of the simulator cueing systems for each training task. The methodology also allows determination of the most cost effective configuration of simulator cueing systems that will satisfy the training requirement. If the cueing systems are inadequate for the training task, this methodology also provides quantitative guidelines for modifying the flight dynamics model to compensate for cueing deficiencies. In Phase I, the proposed methodology will be developed and tested on an in-house OH-58D simulator that ART has tested to FAA Level D standards.

Project 2: Handling Qualities Specification Requirements for Maritime Rotorcraft, VTOL UAV, and Heavy Lift Helicopters

Summary of Services Performed: Developing an aeronautical design standard and simulation toolbox to address the urgent needs of rotorcraft, heavy lift helicopter, and VTOL UAV handling qualities requirements for shipboard operations.

To provide rotorcraft design guidance for military rotorcraft flying qualities evaluation, a modern Aeronautical Design Standard 33, ADS-33E-PRF, was developed under the direction of the U.S. Army as a replacement for the obsolete handling qualities military specification MIL-H-8501A. ADS-33E-PRF addresses rotorcraft flying qualities specification requirements in a novel and comprehensive way so that many of the complicated rotorcraft flying maneuvers can be quantitatively assessed. Compared to MIL-H-8501A, Thus far, ADS-33E-PRF provides design and testing engineers with a comprehensive set of rotorcraft handling qualities requirements for modern rotorcraft design, manufacturing, and testing and evaluation. However, ADS-33E-PRF was developed primarily for land-based rotorcraft operations. The Naval rotorcraft flying qualities requirements were not adequately addressed in ADS-33E-PRF. There is an urgent need to expand ADS-33E-PRF in order to fully address unique Naval rotorcraft technology areas including shipboard rotorcraft handling qualities, VTOL UAVs, and heavy lift rotorcraft design criteria and mission task elements (MTEs).

This SBIR is to develop a technical basis for augmenting the current ADS-33E-PRF to accommodate the needs of improving its applicability to shipboard rotorcraft and heavy lift helicopter flying qualities specifications. The research effort will emphasize the new criteria development, the evaluation methodology formulation, and the analytical simulation toolkit integration. The detailed technical objectives provide the following:

(1) Accomplish a thorough review of the current ADS-33E-PRF and conduct a comprehensive investigation of existing flight test and simulation data to identify areas which need improvement;

(2) Investigate and evaluate land-and sea-based rotorcraft operational differences and propose new specification criteria for shipboard rotorcraft operations;

(3) develop methods for simulation and/or flight test evaluation of the new specification criteria;

(4) Prototype a new handling qualities evaluation toolkit for shipboard rotorcraft operations that is compatible with industry standard simulation programs, such as FLIGHTLAB or MATLAB/Simulink; and (5) prototype the new toolkit by integrating it with FLIGHTLAB to demonstrate the functionality.

Project 3: Enhanced Rotorcraft Aerodynamic Modules to Support Flight Testing
Summary of Services Performed: Developed advanced rotorcraft aerodynamic modules to significantly enhance and improve the analytical prediction of rotorcraft performance, flying quality, and loads in support of vehicle design, manufacturing, operation, and flight testing.

Progress has been made in developing high fidelity rotorcraft simulation models in order to adequately predict rotorcraft performance, stability, and loads in support of design, operation, and flight testing. Limitations, however, exist in several essential aspects of modeling rotor aerodynamics including blade stall, rotor tip effects, rotor downwash, rotor/airframe interference, and rotor aeroelastic interaction.

This SBIR is dedicated to developing advanced rotorcraft aerodynamic modules to significantly enhance and improve the analytical prediction of rotorcraft performance, stability, dynamic response, and loads to support vehicle design, manufacturing, operation, and flight testing. The research and development focuses on five critical application areas: rotor dynamic stall, modern rotor blade tip aerodynamics, unsteady rotor downwash, low speed and high rate of descent, and rotor unsteady loads prediction. The most significant accomplishment of this research is the development of a modern viscous vortex particle model that revolutionizes the modeling of the complicated rotor wake physics. The viscous vortex particle model addresses the rotor wake transportation physics by considering both the effect of vortex stretching while convecting through the flowfield and the effect of air viscosity for the physical vortex diffusion. The model developed is intended to enhance rotor airloads calculation for both performance and vibration analysis. The development also aims at providing a high fidelity rotor wake vorticity transportation modeling tool for complicated rotorcraft aerodynamic interaction analysis.

Project 4: Enhanced Rotorcraft Aerodynamic Modules to Support Flight Testing
Summary of Services Performed: Develop computationally scalable software to utilize massively parallel computer systems to efficiently predict performance and stability in support of flight testing.
This project was to provide computationally scalable tools to predict rotorcraft performance, stability, and control. The ability to efficiently predict vehicle performance, stability, and control from high fidelity computer models would greatly enhance the design and testing process and improved the quality of system acquisition. Through this development, the US Navy Test Pilot School performance, stability, and control test procedures were fully implemented in a high performance parallel computing environment.

Professional Engineering Service Labor rates during contract term

Labor Category	2007	2008	2009	2010	2011	2012
Subject Matter Expert	$349.35	$366.82	$385.16	$404.41	$424.63	$445.87
Senior Software Engineer	$188.32	$203.39	$219.66	$237.23	$256.21	$276.70
Software Engineer	$136.74	$147.68	$159.49	$172.25	$186.03	$200.91
Senior Aerospace Engineer	$155.30	$167.72	$181.14	$195.63	$211.28	$228.18
Aerospace Engineer	$132.92	$143.55	$155.03	$167.44	$180.83	$195.30
Junior Aerospace Engineer	$111.76	$120.70	$130.36	$140.79	$152.05	$164.22

Terms and Conditions

1. Minimum order requirement is $100.00
2. Our Maximum Order Limitation is $750,000
3. Our prompt payment terms are ½% 10 Days, Net 30 Days
4. Delivery time of services will be negotiated with each Federal Agency placing an order
5. ART will accept both Labor Hour and Firm Fixed Price Task orders.
6. ART agrees to make services available under Recovery Purchasing and that the clauses pertaining to Recovery Purchasing will be incorporated into any resultant contracts.
7. ART will accept the Government Credit Card for all purchases
8. Travel will be negotiated with the ordering agency and billed in accordance with the Joint Travel Regulations.
9. ART agrees that any ODCs will be negotiated with the ordering agency.